Social Network Analysis of
Korean Disaster-Safety Industry

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Abstract

Natural disasters and social disasters have been causing more human losses and economic damages over the years. In the modern society, the government alone cannot fully manage disasters, because the number and size of disasters are increasing. Naturally, the role of the private sector in disaster management becomes more important, but there is a lack of studies about the disaster-safety industry. It is need to understand the market of disaster-safety industry to support and grow it. To analyze and understand the current state of the Korean disaster-safety industry, this study adopted the social network analysis technique. The social network analysis is an analysis method to describe the characteristics of the social network, and by using it, the complex industrial networks can be deeply understood.

To collect data, semi-structured interviews were conducted on the K-SAFETY EXPO 2016. The interviews mainly focused on collecting customer information of companies in the disaster-safety industry. Through the interview, basic business information and clients list of 93 companies in the disaster-safety industry are collected. The companies were divided into 8 subdivisions by their related safety sectors, and clients are classified into 15 industry sections for the analysis. The trade networks between the companies of the disaster-safety industry and their clients are analyzed and interpreted with the eigenvector centrality.

By the analysis, it is found that the industrial/construction safety, disaster prevention, and traffic safety are major subdivisions of the disaster-safety industry. 47% of the companies are engaged in multiple industries, and 39% of the companies are engaged only in the disaster-safety industry. Companies in the industrial/construction safety subdivision have the widest range of market in terms of industrial distribution of their clients, and the average client number is high in the industrial/construction safety and the disaster prevention subdivisions. Overall, the public institutes are the most important client type of the overall disaster-safety industry. The disaster prevention subdivision shows a trend that its market is highly relying on their clients by the public institutes. It is also considered that high-value-added service industries and high-tech industry in the disaster-safety industry can widen the possible markets.

This study analyzed the current state of the Korean disaster-safety industry, and found that the current disaster-safety industry market tends to highly depend on the demand of public institutions, therefore, the government-centered policy for growth of the disaster-safety industry is needed. It is also found that there are few transactions between the disaster-safety industry and service industry, so it is needed to study the required role of the disaster-safety industry by the service industry.

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1. Introduction

1.1 Background

According to CRED (Centre for Research on the Epidemiology of Disasters), natural disasters have been causing more human losses and economic damages over the years (as cited in Lee, 2010, pp. 4-5), and so are social disasters, which include large scale industrial accidents, traffic accidents, large fires, and so on,. In order to implement effective disaster management in preparation for such disasters, the capacity of the governmental ministries is important, but voice calling for the improvement of disaster management capacity in the private sector is also increasing these days. Hari (2016) argued that more attention is needed for disaster risk prevention and management, and a risk reduction strategy requires a closer interaction between business and government. The United Nations Office for Disaster Risk Reduction, UNISDR, also has been working with the private sector for over five years for the disaster risk reduction investment of the private sector. According to UNISDR, the collaboration between the private sector, especially enterprises, and governments will build up the disaster resilience of communities (UNISDR, 2015; "UNISDR, Who we work with: Private Sector,"). The importance of participation in the disaster-safety management field of private companies is being emphasized increasingly. The roles of private industries can be one of these things; providing disaster prevention and safety related products, safety management consulting services through cooperation with local government (UNISDR, 2015), developing and implementing disaster management assistance programs, improving disaster consciousness of the public, or providing accurate risk assessment of critical facilities (Hari, 2016).

In Korea, particularly after the Sewol Ferry Tragedy on April 16th of 2014, Koreans have begun to pay more attention to their own safety, because such a cruel destiny could have had been avoided by a better safety management system or a better disaster response system. Not only the public, but also the Korean government have realized the necessity for safety management system improvement. To enhance and improve governmental disaster-safety management capability, the Korean government set up a new master plan for the governmental safety management on March, 2015. The name of the plan is 'the Master Plan for Safety Innovation'. A total of 15 government ministries participated in the plan establishment, and 5 strategies and 100 tasks were included in the plan (*The master plan for safety innovation: 2015 performance report*, 2016, p. 1). In the fourth strategy, 'the expansion of disaster prevention infrastructure and functions', there is a subtask named 'fostering of the disaster-safety field as an industry field'. The purpose of this subtask is developing the foundations for disaster-safety industry development, innovation of disaster-safety R&D, expanding the role of the private sector in the safety field, and promoting investment in safety by the public and the private sectors (*The master plan for safety innovation*, 2015, pp. 36 - 41).

The disaster-safety industry fostering strategy of the master plan includes a subtask of expanding the role of the private sector in the safety field. By this policy, the Korean Standard Industrial Special Classification of Disaster and Safety Industry was established in 2015, and the first survey of the actual industry situation of the disaster-safety industry field was conducted during 2016. The purpose of the classification and the survey is to identify the present conditions of the industry, analyze industry structures, and provide a basis for disaster-safety industry development policies (*Enactment of the Korean standard industrial special classification of disaster and safety industry (draft)*, 2015, p. 1). It is very positive that a survey which aims to find the necessary data for development of the disaster-safety industry is being conducted. However, it also means that current policies and plans regarding the disaster-safety industry may not adequately reflect the current industry situations. Until now, there is lack of data about the current situation of the disaster-safety industry, and the established policies and plans might not reflect the situation adequately. Also, the current industry survey is mostly focused on collecting general statistical data from companies, and it might be not enough to find or understand networks and relationships between companies and their clients.

If industrial connections could be understood, such as their trading networks, research and development (R&D) networks, or collaborations between companies, it would help the government and experts to understand the disaster-safety industry more deeply. Social Network Analysis (SNA) can be a way to find an answer in this situation. It is one widely used research technique in the field of social science. Compared to traditional social science research techniques, this technique has some advantages. The social network analysis technique can be used to analyze complex interactions which occur between participants of various networks including political networks, coauthor networks in academic fields, or industrial networks, which cannot be understood through traditional analysis techniques. In the industrial engineering field, researchers can identify structural characteristics of an industry sector, , or find a way to optimize management and marketing strategies of a company using the social network analysis technique (Kim, 2011).

A characteristic the disaster-safety industry field is that it is blended with numerous other industry fields, and companies can expand their markets through it (Cheung & Yoon, 2015). By analyzing industrial networks, there could be some industry fostering strategies developed. For example, the government can plan to strengthen the networks' weaker links between market and companies in the disaster-safety industry field, which would then expand the scale of the disaster-safety industry as the network is strengthened.

1.2 Purpose of the study

The main purpose of this study is to develop a growth strategy for the disaster-safety industry by analyzing its current situation, focusing on Korea. Using the social network analysis technique, the current state of the Korean disaster-safety industry will be analyzed, along with its characteristics, and the ideal role of the government.

This study has a differentiation that it analyzes the disaster-safety industry through its transaction data. Also, this study divided the disaster-safety industry into eight subdivisions; natural disaster prevention, industrial/construction safety, traffic safety, fire safety, living safety, security, hygiene/health, and miscellaneous. Existing studies have focused on finding the industrial characteristics by using traditional industry classification, which classify industries by their functions, for example, manufactures or wholesales. However, this study divided industries by considering the specificity of the disaster-safety field, so it brings a new perspective to the disaster-safety industry.

The significance of this study is that its findings can help policy makers to set up and implement better future disaster-safety industry related policies for industry expansion. As the disaster-safety industry grows, it can bring both economic growth and an increase in disaster management capacity.

2. Literature Review

2.1 The private sectors in the disaster management

2.1.1 Role of the private companies in the disaster-safety industry

Because the number and size of disasters are increasing (Lee, 2010, pp. 4-5), disaster management capacity of the Korean government cannot fully cover disasters in modern society. Traditional disaster management has relied heavily on the management capability of the government. It has been recognized as a field that only the government takes charge of, but this trend is changing in modern society. Although disaster-safety management still has characteristics of public goods in the market, the importance of the private sector is increasing. Many countries and organizations argue that the role of private sector is becoming more important, and there is a need to systematically manage disaster management by linking resources and capabilities of private sectors with the government for effective disaster management.

The necessity of the private sector in the disaster-safety management has been raised for the following issues. Most facilities and properties that are damaged by disasters belong to the private sector. In the case of U.S., about 85% of these facilities are private. Because of this, effective disaster-safety management can be achieved by the participation of the private sector (Abou-Bakr, 2012).

The United Nations Office for Disaster Risk Reduction (UNISDR) declared five visions of the private sector for future resilience. It argues that strong partnership between the public and private sectors can strengthen the disaster risk reduction and resilience of communities. To achieve this, the role of the private sector is to provide products and services to meet local needs, and the private sector also needs to raise awareness that these partnerships are mutually beneficial. The overall content of the UNISDR claims is that in the field of disaster safety management, services and technical levels such as consulting, education and risk assessment by the private sector should be increased (2015).

Hyogo framework for Action, which is the main outcome of the world conference on disaster reduction held in Kobe, Hyogo, Japan, 22 January 2005 by UNISDR ("About the Hyogo Framework for Action (2005-2015),"), is a ten-year plan for a safer world to reduce the damage and threat of natural hazards. The first plan, aims on the resilience of buildings, and describes the role of all sectors involved in the disaster management, including governments, international agencies, disaster experts, the private sector, and others. The role of the private sector claimed by UNISDR is spreading disaster prevention culture for public and government around the world and allocation of disaster management resources for disaster risk reduction. UNISDR claims that the public-private partnership is necessary to achieve this (2005).

Witt, Sharma, and Lill (2014) argued that improving the disaster resilience of society can be achieved by continual re-assessment of the current regulations, guidance, and industrial environment. Hari (2016) argued that the advantages of the private sector come from their large potential, which can provide high quality goods, skilled services, and technical manpower. The private sector can frequently interact with the public, so it is easy to satisfy the necessity of communities. Therefore, the private sector can act as a bridge which connects a gap between the government and the public. Also, the amount of goods and service capabilities provided by the private sector cannot be neglected. Many activities needed during emergency situations, for example, public information, emergency medical support, and debris removal, should be processed quickly and accurately, and the proper use of private sector capability can certainly be helpful.

2.1.2 Capacity building for the private disaster-safety industry sector

Despite the increasing importance of the private sector in disaster management, according to Oh (2016, pp. 15 - 16), there are not many studies about the role of private companies in the disaster management, so it has been claimed that research about the way to increase participation of private companies in disaster-safety management from a national wide perspective is needed.

Hari (2016) argued that government and local authorities should make and utilize a more effective framework to maximize the capability of the private sector. The framework may include policies directly supporting industrial operations or indirect support like incentives. Also, Abou-Bakr (2012) argued that the private sector can approach a disaster or accident more quickly than the government and mobilize the resources needed to respond to the disaster when the government supports the private sector by distributing and allocating disaster management resources to the private sector. The study of Oh suggested that it is necessary to strengthen the diagnosis of the safety industry through cooperation between the government and the private sector, and argued that it is necessary to strengthen the support to the disaster-safety industry by establishing the legal system base (Oh, 2016, pp. 243 - 257).

Yoon (2015) investigated the present state of domestic disaster prevention technology and industry and insisted that a performance certification technique is necessary. Through an analysis of the domestic disaster-safety industry, Yoon found that most companies in the disaster prevention field are manufactures and constructors, and the main subject of research and development in the natural disaster management is flood, heavy rain, tsunami, and earthquake. The results of the study showed that disaster prevention technology needs to advance to the international market, by having the technological competitiveness in the international society through governmental support.

2.2 Industrial classification of the disaster-safety industry

There is not a global standardized industry classification for the disaster-safety industry. The definition of disaster-safety industry field varies from countries to countries. For example, the National Fire Protection Association (NFPA) is an American organization which is famous for its codes and standards for fire protection. The NFPA designates and provides various types of codes and standards about the fire safety, including industrial classifications of fire protection, electrical machinery, personal protective equipment, life and health care, and so on.

In Korea, there are three disaster and safety related industrial classifications in the disaster-safety management field. The Korean government designated these to be the fire protection industry, the natural disaster prevention industry, and the disaster-safety industry. The purpose of classifying industry is to clarify the definition, scale and scope of an industry and to lay the foundations for industrial promotion and policy formulation ("Korean standard statistical classification,"). The disaster-safety industry classification covers seven safety fields; natural disaster prevention, fire safety, facilities and construction safety, transportation safety, industry safety, living safety, and hazardous materials safety

(*Enactment of the Korean standard industrial special classification of disaster and safety industry (draft)*, 2015). However, many parts of this industry classification overlap with previous industry classifications, the fire protection industry and natural disaster prevention industry. Previous research argue that integrated operation of classification is needed to avoid duplication (Lim & Park, 2016; Oh, 2016, p. 250).

2.3 Social network analysis

Until now, the importance of disaster-safety industry and the efforts to classify disaster-safety as an industry have been discussed. However, structural analysis of the present situation of the disaster-safety industry is still lacking. Although there are some basic statistics such as industrial statistics, the unique structural features of the disaster-safety industry have not been identified. It is difficult to understand the structure of an industry solely based on statistical data, which can only represent the situation of the whole industry. Especially, the disaster-safety industry, whose definition and industrial range are ambiguous, need an understanding from different approaches.

The social network analysis is an analysis tool which analyzes the network composed of various stakeholders. A network is a social form which enables inter-organizational interactions, exchange relations, union behavior, and co-production (Alter & Hage, 1993). By analyzing the disaster-safety industry network, it can be understood that the current structure of the industry and what interactions are taking place in the industry. This approach not only helps to gain an overall understanding of the disaster-safety industry, but also allows to see how the relationship is formed between the members of the industry and the position of each member in the industry. One of approaches of the network analysis is the positional approach. The main aims of positional approach is that where members locate in the network and what their roles are (Burt, 1980). This approach identifies relationship between members as an directed or undirected relationship, and these relationships form the position of each member (Keast, Mandell, Brown, & Woolcock, 2004), and this study adopted the positional approach to interpret the industry network to identify the role and importance of network members, focusing on the clients of the disaster-safety industry.

2.3.1 Theoretical background of the social network analysis

According to Yoon and Chae (as cited in Kim & Chang, 2010), A social network means a network of connections between people, which is naturally made by the interaction of various stakeholders. Social network analysis is an analysis method the purpose of which is to describe the characteristics of a social network, to explain the characteristics of the system as a relationship, and to describe the behavior of the unit in the network (Kim & Kim, 2016, p. 5). A network consists of two components, node and link.

Node is a point representing a unit or member of the network, for example, it can represent an individual, company, country, or others. Link means the connection established between two nodes. It is represented with a line in the network. Density, centrality, and centralization are most widely used indices for social network analysis (Kim, 2011; Kim & Chang, 2010).

Density is a measure of how many members of a network are related to each other. It is calculated as the ratio of the number of relationships actually made out of the total number of possible relationships. The number of relationships is called as a degree, which indicates between a node and other nodes.

Centrality describes the extent to which a node is located centrally in the entire network. There are various kinds of indicators that show the centrality. For example, there are degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality. Degree centrality is a sum of the number of connections from a node. Closeness centrality is a degree that measures how a node is closely located to other nodes, and betweenness centrality is a degree that measures how many nodes are linked through a particular node. Eigenvector centrality is a centrality which weighs a node according to the importance of its connected nodes, so it is also called the prestige centrality (Kim & Kim, 2016, p. 126). For this reason, Bonacich (1987), who suggested the eigenvector centrality, argued that eigenvectors can be used as a good network centrality measure. It is also useful to figure out a network whose structure is varied in degrees (Bonacich, 2007).

2.3.2 Industry analysis using the social network analysis

Many researchers have adopted social network analysis as a key analysis tool for their research. In previous studies about industry network, the social network analysis approach was used in various types of industrial fields. The existing studies mainly focused on identifying the structure of the industrial networks, identifying cooperation networks, classifying networks by their characteristics, and so on.

Hong (2006) analyzed the production and flow of the science and technology information using the social network analysis, focusing on the field of biosafety related organizations. Using degree centrality values, information flow networks were drawn by the type of organizations. Through the centrality values, the information flow characteristics of each organization type were derived, and political implications were suggested.

Calero, van Leeuwen, and Tijssen (2007) conducted network analyses to identify the status of research collaborations of the bio-pharmaceutical industry. They used the co-publications data to understand how the research cooperation connections exist within or between companies. Through the study, networks are divided into centralized research cooperation networks and decentralized research cooperation networks by their network structures.

The study of Kim, Choi, Yan, and Dooley (2011) used the social network analysis approach to investigate the supply network of the automotive industry. The two properties, material flows and contractual relationships, of supply networks were analyzed. The supply networks were interpreted with various indicators including network size, density, degree, and centralities. The authors concluded that the social network analysis approach can complement the traditional case study based approach as investigation tools for industrial networks.

Lee and Na (2013) analyzed the network structure of the wind power industry using social network analysis. They aimed to analyze the production chains of each sub industrial part. They found that, overall, the wind power industry in Honam region of Korea is strongly connected with other industries, and the metal products and mechanical components industry are dispersed, so the wind power industry is the centered industry and highly affecting other industries.

Kim (2014) conducted asocial network analysis to understand the networks of local organizations which participate in the cultural industry cluster in Daegu, Korea. The interactions between organizations and the core organizations of the industry network were analyzed. The author found that cluster participating organizations have a low degree of interaction using the centrality values. The author also figured out the reasons for low number of interactions, and suggested some improvements.

Lee (2014) analyzed the characteristics of the production and supply networks of the online game industry. The author used degree centrality to interpret characteristics of the networks, and figured out the factors contributing to those characteristics using the commodity chain and value chain theories.

Park (2015) used the social network analysis technique to figure out the characteristics of contraction networks of public construction projects in Korea. He divided the organizations into two types; orderer and main-contract, and figured out the characteristics of networks as either one-sided projects or cooperative projects. The author suggested that the contribution of social network theory can make the cooperation improvement and balanced growth of industry by using it as an evaluation tool for an industry.

Jang (2016) analyzed the cooperation network of a local fashion industry cluster using social network analysis. Centrality analysis, network density, cohesion, and structural equivalent, and other analysis methods were used for the social network analysis, and factories in the fashion cluster were clustered and the characteristics of those clusters were analyzed.

There are numerous studies which investigated the industry structure, and analyzed the characteristics of industry structures using the social network analysis approach. However, there is a lack of research on the current state or the structure of the disaster-safety industry. Therefore, this study used the social network analysis to study the disaster-safety industry that has not been studied yet.

3. Methodology

3.1 Study design

This study aims to identify the current situation and trade networks of the Korean disaster-safety industry. Both quantitative and qualitative approaches are adopted. quantitative statistical analyses are conducted primarily, while a qualitative approach is used for the industry interpretation process.

The disaster-safety industry is not an industrial sector that can be grown and expanded by general market principles. It is necessary to grasp the structure and characteristics of the disaster-safety industry to overcome its limitation. Unfortunately, statistical data for quantitative analysis on disaster-safety field engaged companies are not currently available. Therefore, in this study, semi-structured interviews were conducted to establish a dataset for quantitative analyses, and the interview targets are selected as companies which participated in the second Korea International Safety and Security Expo (K-safety expo 2016). The main focus of the interview questions is the current state of companies and their trading networks. Using current state data obtained from the interviews, several simple statistical analyses were conducted to understand the characteristics of companies in the disaster-safety industry. Using the trading networks data, social network analysis was also conducted to analyze the structural characteristics of the disaster-safety industry.

3.1.1 Data collection through the semi-structured interview

To collect data, semi-structured interviews were conducted based on a built survey form. The semi-structured interview is a widely-used survey method for qualitative research, but also used for quantitative research. It is an interview method in which all candidates have the same list of questions and topics, but interviewers have flexibility in the way the interview progresses. Unlikely to a standard questionnaire survey or a structured interview, it allows more responses and ideas to be included through the interview. At the same time, because it uses a structured and standardized form of questions, the interview results remain at a high level of validity even if more than one interviewer participate (Edwards & Holland, 2013, pp. 29 - 30).

The semi-structured interviews were conducted over two days, 17th and 18th of November, 2016, at K-safety Expo which is located on Ilsan, Goyang-si, Gyeonggi-do. The interview was carried out by a total of eight interviewers, including the researcher. All interviewers were educated enough about how they should ask and record responses, before the interview started. The interview targets were companies in the disaster-safety industry field, and each individual interview took less than 15 minutes to complete. Because interviews were not pre-arranged and interviewees were not given times to prepare the answers, the quality of answers, collected information, are up to interviewees' knowledge of his/her company. If an employee with a low level of knowledge of his/her business responded, the quality and accuracy of collected data could be reduced. Therefore, the interviewers tried to interview with a people of high rank in a company to avoid such problems. However, since it is still possible to acquire incomplete data, after the end of all the interviews, additional information of clients was collected through websites and catalogues of companies to obtain objective data.

3.1.2 Target of the interview

To clearly select the interview targets, the structured interviews were targeted at companies which participated in the K-safety expo 2016, which is the largest tradeshow of the safety and security industrial field. It was held in KINTEX, Ilsan, and hosted by the Korean government. The exhibition largely consists of six sectors; natural disaster prevention and industrial safety, security and anti-terrorism, public safety service, traffic safety, maritime safety, and hygiene and health. Based on these sectors, companies that responded to the interview were reorganized into eight subdivisions of the disaster-safety industry according to their specialized fields; natural disaster prevention, industrial/construction safety, traffic safety, fire safety, living safety, security, hygiene/health, and miscellaneous. These classifications were used for the categorizing companies in the social network analysis.

According to the secretariat of the exhibition, a total of 230 organizations participated in the K-safety expo 2016. Among them, 168 organizations were business companies, and the remaining 62 organizations consisted of government ministries, public enterprises, universities and academic organizations, press, and NGOs. The purpose of this study is to understand the current situation of domestic disaster-safety industry, so all other types of organizations listed above were excluded from the interview. Among the 168 business companies, 93 companies responded to the interview while 75 companies refused to response (response rate: 55.4%). After the data organizing progress, two of the responses that were not recorded with enough information were excluded from the analysis and finally 91 responses were used for the analysis.

The interview sample group is purposively selected within a limited population, not the entire population of the disaster-safety industry, so the sample selection method is the convenience sampling method. The reason for this purposive sample selection is that the exhibition is the largest safety industry related tradeshow in Korea. It is therefore considered that participation in this expo can be an indicator the level of interest in the industrial field of a company, i.e. whether it is enrolled in the disaster-safety industry or not ("K-SAFETY EXPO 2016 website,"). Therefore, the participating companies are regarded as important and passionate companies in the disaster-safety industry, and were selected as the sampling target.

3.1.3 Composition of questionnaire

The interview form consisted of four parts; overview information of company, industrial status, industrial networks, and the intention of business relocation. The first part, overview information of company, included two questions which were needed to determine the size of the company. The number of employee and last year's sales of the company were asked in this part. The last year (2015)'s sales were asked for a specific amount in numerical value at first. If the respondent was reluctant to say a specific number, then five categories of sales were suggested and he or she was asked to answer it again. The suggested five categories of sales were 'less than 100 million won', 'more than 100 million and less than 1 billion won', 'more than 1 billion and less 2 billion won', 'more than 2 billion and less than 5 billion won', and 'more than 5 billion won'.

The second part, investigation of industrial status, contained four questions asking how much disaster-safety industry has meaning to a company. It asked whether the company was only in the disaster-safety field at the time or also in another industry field. When the company responded that it is also in another industry field, they were asked whether the disaster-safety field is the main business part of the company. If the industrial origin of the company was not the disaster-safety industry, the interviewer also asked which sector the company came from. Also, further questions were asked to figure out which parts the company could be classified by the Korean Standard Industrial Special Classification of Disaster and Safety Industry.

The third part consisted of questions for identification of industrial networks. This part mainly focused on revealing trade networks, competitor networks, and R&D networks. It was the most important part of the interview, because the industrial network analysis is the main topic of this study. The interviewer asked the names of organizations where the company trades, and confirmed the type of main trading organization. The suggested types of main trading organization were government agencies and public enterprises, businesses, individuals, or others. Since interviewees usually could not list all the trading organizations of his or her company, the trading data was supplemented through the company catalogue and homepage later. The interviewer also asked the name of competitors, but companies usually responded that every company in the same industry is their competitor and they do not have specific competitors. Therefore, there were not many responses recorded to this question.

The next question was the name or type of organization they would be interest in regarding future deals.

Unfortunately, not many responses were recorded for this question, too. There were some responses like government organizations, major companies, and overseas companies, but most responses did not mention a specific organization name, so are not clear enough to compose the network. The R&D status was asked, and how the company conducts research and development was asked if the company answered that it does research and development. Most companies which do research and development responded that they have their own laboratory or research department. Some responded that they conduct R&D with other organizations; other companies or research institutes of universities.

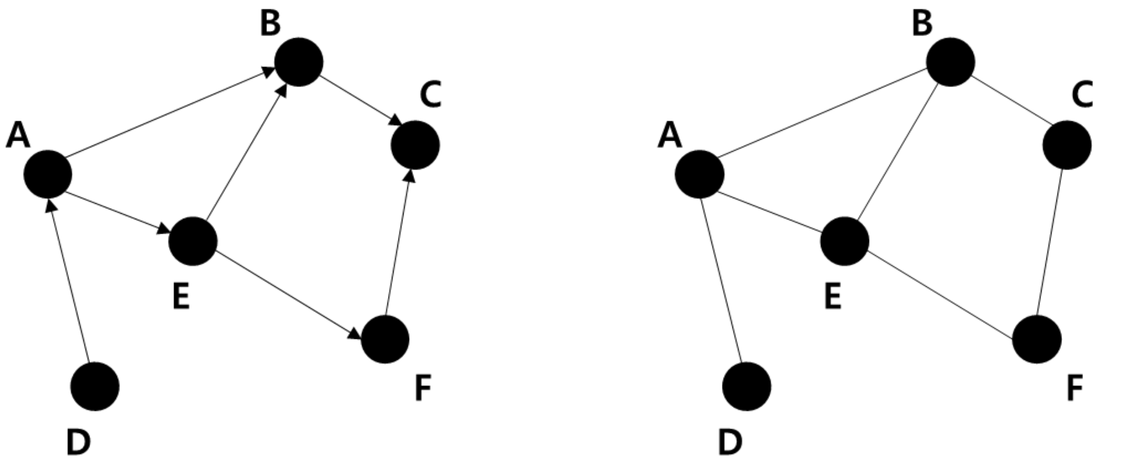
The last part of the interview asked whether they had any intention to relocate their business. There were three questions, factors contributing to the choice of current business location, important factors for business location selection, and the intention, or plan, for business relocation. During the interview, examples of location selection factors were suggested. Four location selection factors were selected by referring to previous studies; customer accessibility, transportation accessibility, support of local government, and industry integration (Kim, Seo, & Oh, 2012; Lee, 2016; Scott & Angel, 1987). The interviewer suggested those factors, but all responses were also recorded by the interviewer. Once the intention of business relocation was asked, additional questions were asked based on the response. If a company responded that it had an intention or plan for relocation, the interviewer again asked the intended location and reasons. If a company responded that it had no intention or plan for relocation, the interviewer asked the reasons.

3.2 Social Network Analysis

To perform the social network analysis, the open source software Gephi was used in this study. The Gephi software has some advantages compared to other network analysis software. Gephi is suited for visualization of huge data, and it is relatively easy to use with a graphical interface and allows broad access and exploration of networks (Kim & Kim, 2016, pp. 311 - 321). The most unique feature of Gephi is the visualization function. Using various design algorithms, Gephi makes its user visualize a network and understand it easily, with the help of its special 3D render engine, which makes the graphic rendering process in real-time (Bastian, Heymann, & Jacomy, 2009).

The trading network between companies and the type of their clients are analyzed using the social network analysis approach. The clients of companies in the disaster-safety industry are classified into fifteen client types, and the connection between the companies and client types are analyzed. The two largest subdivisions of the disaster-safety industry; the industrial/construction safety subdivision and the natural disaster prevention subdivision, are analyzed separately for deeper understanding.

There are two types of connections in the network, directed connection and undirected connection. A directed connection has a starting node and an ending node, which the relationship between two nodes is directional. For example, one node gives information unilaterally to another node. The undirected connection assumes that two connected nodes have a mutual relationship between them. *Figure 1* illustrates a directed graph and an undirected graph. In the directed graph, connections of the node 'D' affects the node 'C', through the other nodes. However, the node 'C' do not affect the node 'D', because the connections do not extend from the node 'C' to 'D'. In another graph, the undirected graph, every connection connects both nodes evenly, and the path from the node 'D' to the node 'C' and the path from the node 'C' and the node 'D' are theoretically identical. In this study, the connection between a company enrolled in the disaster-safety industry and its client is assumed as an undirected connection. Usually the connection between a company and its client are assumed as a directed connection in the concept of supply. However, this study focuses on the fact whether those two organizations know each other rather than their trading relationships. Therefore, those relationships are thought as social connections, and the networks are illustrated as undirected graphs in the analysis.



(a) A directed graph (b) An undirected graph

Figure 1. A directed graph (left) and an undirected graph (right)

The layout method is important to express results of the social network analysis. Proper layout is not only useful for better visual of a graph, but also useful to explore the data, data structure, and relationships in the graph. This study used the ForceAtlas layout of Gephi to express the figures represented in the study. The ForceAtlas layout allows a rigorous interpretation, low level of biases, and better readability of the graph ("Gephi tutorial layouts," 2011, p. 11). The ForceAtlas layout algorithm is a force directed layout, which means it simulates a kind of physical system to visualize the graph. Nodes push each other and edges attract their connected nodes. These two contrasting forces, repulsion and attraction, create a balanced state of the graph (Jacomy, Venturini, Heymann, & Bastian, 2014). By this layout algorithm, connected nodes whose edge degree is high locate closer, in other words, nodes that are highly related to each other are located adjacent to each other in the graph. Although the layout itself cannot make a full interpretation of a network, it is helpful to understand the network.

3.2.1 Industry classification of clients

The type of clients, trading organizations of the disaster-safety industry companies, was reclassified and simplified to make a clearer network of the companies and their clients. From the raw data of clients of interviewed companies, it was largely divided into service industry, manufacture industry, and others. Finally, it was divided into fifteen industrial categories (see Table 1). By referencing the Korean standard industrial classification, the service industry was divided into six sub-industries; business management services (S-BM), food services (S-F), general services (S-G), information and communication services (S-IC), professional technical services (S-PT), and security system services (S-SS). The manufacturing industry was classified referring the study of Hong and Song (2016).

Hong and Song (2016, p. 101) reclassified the industry classification into 6 categories. They reclassified the manufacturing industry into three types, the manufacture of consumer goods, the manufacture of basic materials, and the manufacture of fabricating and processing equipment. The non-manufacturing industry was also reclassified into three types, social overhead capital (SOC) and construction industry, distribution industry, and producer service industry (see Table 2). In this study, the manufacturing industry classification made by Hong and Song (2016) was adopted and the manufacturing industry classification is divided into three sub-categories.

Industries and organizations which are not included in both service and manufacturing service are classified in the other industries group, also based on the Korea standard industrial classification. It consists of construction and works (CW), financial and insurance (FI), medical institutions (MI), public institutions (PI), wholesale and retail trade (WRT), and unclassified industries.

Table 1

Industry classification of clients used for the social network analysis.

Type	Classification	Code
Services industry	Business Management Services	S-BM
	Food Services	S-F
	General Services	S-G
	Information and Communications	S-IC
	Professional Technical Services	S-PT
	Security System Services	S-SS
Manufacturing industry	Manufacture of Basic Materials	M-BM
	Manufacture of Consumer Goods	M-CG
	Manufacture of Fabricating and Processing Equipment	M-FPE
Other industries	Construction and Works	CW
	Financial and Insurance	FI
	Medical Institutions	MI
	Public Institutions	PI
	Wholesale and Retail Trade	WRT
	Unclassified	U

Table 2

Reclassified industry classification by Hong and Song (2016).

Division	Industry group	Sectors
Manufacturing industry	I. Manufacture of consumer goods	Food, beverage, tobacco, textile, garment, leather, wood, pulp paper, printing, furniture, other manufacturing
	II. Manufacture of basic materials	Petroleum, chemicals, medical materials, rubber and plastics, nonmetallic mineral, primary metal
	III. Manufacture of fabricating and processing equipment	Metal processing, electronics, precision machinery, electricity, machinery, automobile, shipbuilding
Non-manufacturing industry	IV. SOC/construction industry	Electric and gas, raw material recycling, construction
	V. Distribution industry	Wholesale and retail, transportation
	VI. Producer service industry	Publishing, AV, broadcasting, communication, system, information processing, real estate leasing, professional science and technology services, business facilities management, business support service

Note: Reprinted from The Comparative Analysis on the Supply-the Demand Networks in Regional Industry, by Hong and Song. Copyright 2016 by Korean Association of Regional Studies.

3.2.2 Indices for the network analysis of industry structure

To figure out the structure of networks through an objective index, the eigenvector centrality was used. The eigenvector centrality is appropriate when differences of degree occupy an important position or indicator in the network (Bonacich, 2007). The calculation of eigenvector centrality measures the importance of a node in a network based on its connections. This study tries to find the important organizations or industrial types for the disaster-safety industry, so using the eigenvector centrality is expected to be helpful for industry analysis.

The equation of the eigenvector centrality is as follows. Let $A = \left(a_{i_\gamma j}\right)$ be the adjacency matrix of a graph, and x_i be the eigenvector centrality of node *i*. Then the eigenvector centrality x_i is given by:

$$x_i = \frac{1}{\lambda}\sum_k a_{k_\gamma i} x_k \quad (\lambda \neq 0)$$

It can be expressed as $\lambda x = xA$ in matrix form, and the unique and positive eigenvector value *x* is calculated by solving the equation. The calculation process of the eigenvector centrality contains a normalization process, so the maximum eigenvector centrality of a network is normalized as 1. This characteristic also useful when several networks are analyzed. Because the eigenvector centrality value is already normalized, eigenvector centrality values in different networks can be easily compared. In other words, the importance of same node in different networks also can be easily compared using the eigenvector centrality values.

4. Results

4.1 Characteristics of Disaster-safety industry of Korea

The interviews also collected several data about general status of companies, not only data for the social network analysis. In this chapter, the general status and characteristics of the data used in the analysis will be listed. 91 responses were used, and companies were classified according to their detail sectors in the disaster-safety industry by the objective of the company. As *Figure 2* illustrates, most companies are in industrial/construction safety. 21 companies are working in the industrial/construction safety sector, and their main products are accident prevention devices such as safety helmets, hazardous elements detection devices such as gas leaks, and safety systems or solutions for industrial sites and factories. As the second most, 18 companies are engaged in the sector of traffic safety. The main products of the traffic safety sector are devices preventing traffic accidents, raised pavement markers, and road signs. Few companies deal with high-tech industry like traffic information system, and most companies are manufacturers. The third most represented sector is the natural disaster prevention, with 17 companies. The main products of the natural disaster prevention sector are about mitigation of natural disaster damage; for example, seismic isolation systems and flood damage prevention facilities. It clearly reflects the disaster management characteristics of Korea. Conventional disaster management of Korea focuses on flood management, so many companies are engaged in the flood disaster prevention field. It is estimated that a large number of earthquake related companies participated in the K-safety expo 2016 due to the recent earthquakes in Korea.

The number of responding companies in the fire safety, living safety, and security sectors are about ten each. The companies in fire safety mainly deal with fire extinguishing equipment and systems. Companies in the living safety field deal with various fields, not one specific field of living safety. The security related companies focus on image information systems and communication security. The companies in hygiene/health and miscellaneous are only two each. Companies in health safety sector are trading the Automated External Defibrillator (AED). Because of the lack of these samples, these parts will not be mentioned much in the rest of the paper.

All 91 companies answered the question that asked whether the company were only in the disaster-safety industry or also in other industry at the time. 35 companies (39% of the responding companies) answered that they were only in the disaster-safety industry. 43 companies (47%) answered that they were in both the disaster-safety industry and other industries. 13 companies (14%) answered that their main industry sector was not the disaster-safety industry although they participated in the exhibition (see *Figure 3*).

As was expected, many companies are engaged in multiple industries, not only in the disaster safety industry. One of the characteristics of the disaster-safety industry is that it is usually mixed with other types of industry. For example, a company whose main sector is civil engineering can participate in a dam construction project or other structural disaster mitigation projects, and a company which engages in the field of internet of things (IoT) can utilize its techniques to make a safety surveillance system for construction sites. It means that the disaster-safety industry has high accessibility and low entry barriers from other industry fields, so proper support and policies could increase the number of companies which engage in the disaster-safety industry.

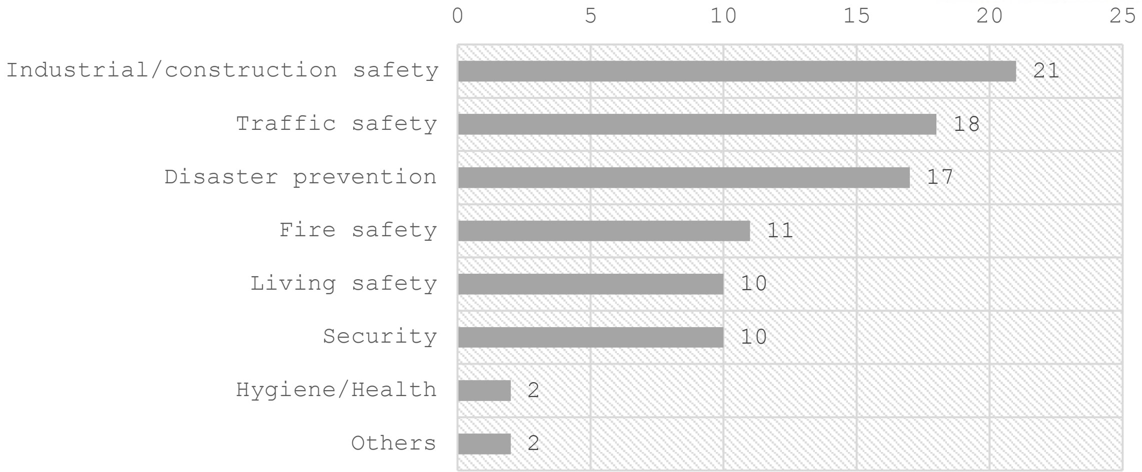


Figure 2. Sector distribution of the interview responded companies.

Figure 3. Industrial distribution of the interview responded companies.

Clients are the most important thing in business. *Figure 4* illustrates a summary of the responses to the question asking the types of major clients. The major customers of the companies in the disaster-safety industry are found to be businesses (53 responses) and government agencies (45 responses), including public enterprises. Unlike what was expected, there is not much difference in the number of responses reporting business and the number of responses reporting government agencies/public enterprises. Moreover, the number of interviewees that responded business is greater than the number of interviewees that responded government agencies/public enterprises. These results are interesting because, in general, major customers in the disaster-safety industry are thought to be government agencies and public enterprises.

To learn more about this topic, the responses were tabulated by the subdivisions of the disaster-safety industry (see Table 3). The percentage values in the table are the percentage of companies which responded that the type is the main customer type; business, and the government agencies and public enterprises. If the company replied that both types, business and the government agencies/public enterprises, are their main customer types, then the sum of two response rates may exceed 100%, because both items are counted. From the table, it can be seen that industrial/construction safety, living safety, and fire safety fields are mainly trading with private businesses. The natural disaster prevention field is the only subdivision which is highly focusing its market on government agencies and public enterprises. The main customer type of traffic safety and security subdivisions are relatively similar.

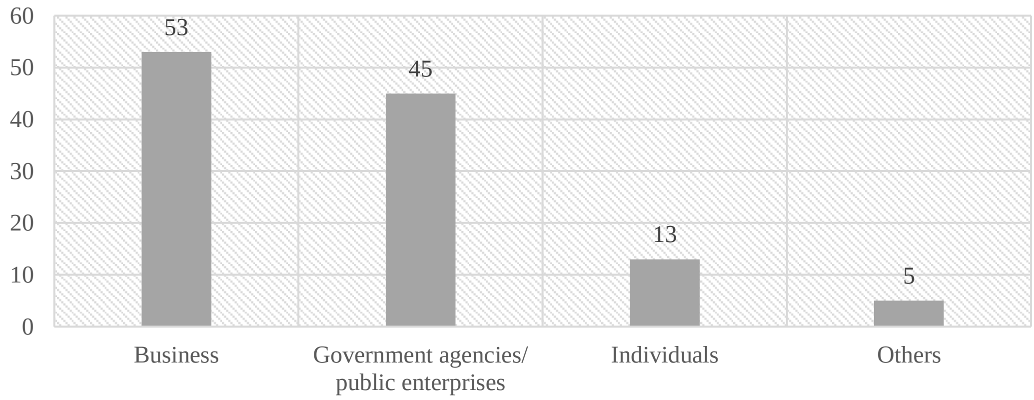


Figure 4. Types of major trading organizations (multiple responses allowed).

Table 3

The percentage of the main customer type by each subdivision (multiple responses allowed).

	Main customer type	
	Business	Government agencies/ public enterprises
Traffic safety	41.7%	50.0%
Natural disaster prevention	17.6%	82.4%
Industrial/construction safety	85.7%	42.9%
Living safety	72.7%	45.5%
Security	55.6%	55.6%
Fire safety	72.7%	27.3%

Note: The hygiene/health and miscellaneous subdivisions are excluded because the number of their sample is too small.

4.2 Structural characteristics of Disaster-safety industry networks of Korea

Of the 93 interviews, it was not possible to find out the customer information of 11 companies. Therefore, the network is composed of the remaining 82 companies. *Figure 5* illustrates the trading network of the 82 disaster-safety companies and the entire 271 clients. The graph illustrates the entire trading network of collected data, and indicates some important clients, for example, local government, large construction companies, and so on. Although representing each organization with each node is better to identify the characteristics of individual nodes, it was ambiguous to understand the structure of the entire disaster-safety industry. Especially, it would be more meaningful to understand the characteristics of the client type, which represents the industry classification, rather than identifying the characteristics of each client. Therefore, the analysis was conducted focusing on the categorized client information, the industry classification.

Figure 5. The trading network between companies and their trading client of Korean disaster-safety industry. The brighter node color indicates higher values of eigenvector centralities, and the size of the node is proportional to the eigenvector centrality of each node.

Using the categorized client information, the trading networks between companies and client types are made. At first, all subdivisions in the disaster-safety network were included in the network. From this network, it was found that the industrial/construction safety subdivision and the natural disaster prevention subdivision have some noticeable characteristics in the network, so further analyses were conducted, focusing on those two subdivisions. The interpretation of the network is conducted based on the value of the eigenvector centrality, and the client types in the important positions are found.

4.2.1 The trading network between companies and client types

The trading networks between companies and trading industry classification are analyzed by using the social network analysis approach. A total of 83 companies and 15 organization types are included to form the trading network with 220 connections (links). The average degree, in other words, connections of each node, is 4.536 and the average weighted degree is 10.371. The graph density is 0.047. The network indicates that the most important types of industry classifications for the disaster-safety industry are public institutes (PI) and manufacturers of fabricating and processing equipment (M-FPE), and both industry classifications have high values of eigenvector centralities (see Table 4). An interesting thing is that manufacturers of fabricating and processing equipment (M-FPE) and construction and works (CW) have similar weighted degrees, which indicates they have similar number of trades in the network, but the eigenvector centrality of M-FPE is larger than that of CW. This means that M-FPE has more influence on the trading network of disaster-safety industry, because more companies have transactions with M-FPE (34 companies) than CW (22 companies). It can be interpreted that the market of M-FPE is larger than that of CW, and the construction and works industry has a characteristic that trading tends to be concentrated in just a few companies.

The eigenvector centrality values also indicate that there are few transactions with the service industry in the disaster-safety industry market. Generally, the eigenvector centralities of some secondary industries, for example, M-FPE, CW, and M-BM, are high but some service industries and financial business which are in tertiary industries do not have many trades with the disaster-safety industry.

In *Figure 6*, The green color nodes indicate companies in the natural disaster prevention part, and the purple color nodes indicate companies in the industrial/construction safety. As *Figure 6* illustrates, green color nodes are more likely to be located near the public institutions node, and purple color nodes relatively far from the public institutes node. The companies in the natural disaster prevention field are mainly involved in disaster management of natural disasters, so it is considered that the demand from the public institutions is the largest. In contrast, the companies in the industrial/construction safety field usually sell safety and protection goods to factories and construction sites, so their main customers are factories and construction companies. More detailed analyses of the characteristics of each subdivision of the disaster-safety industry will be given in the later section.

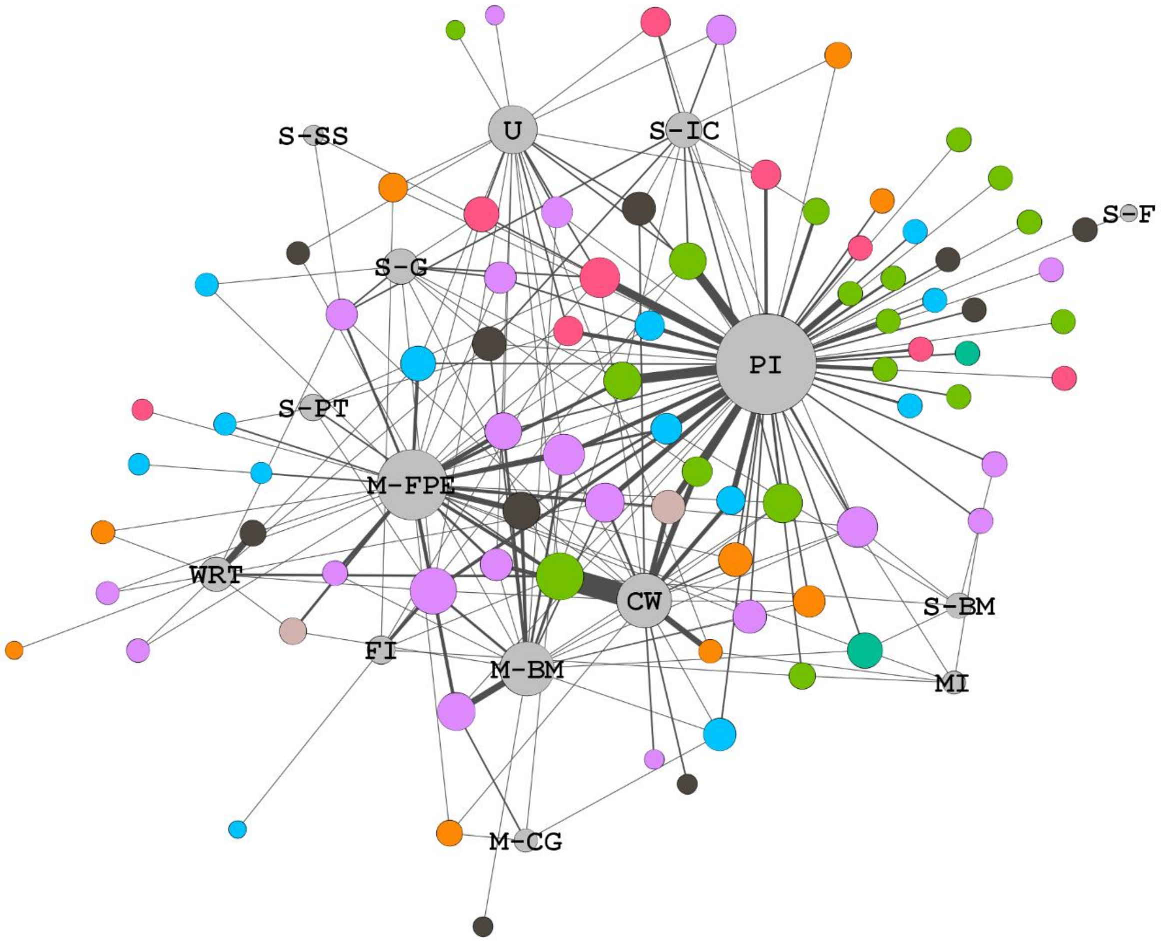


Figure 6. The trading network between companies and their trading client types of Korean disaster-safety industry. The node color indicates the disaster-safety industry sector of each company, and the size of the node is proportional to the eigenvector centrality of each node. Thickness of edge is proportional to the weight.

Table 4

Eigenvector centrality values by the industry type from the trading network between companies and their trading client types.

Rank	Industry type	Eigenvector centrality	Weighted degree
1	Public Institutions (PI)	1.000	191
2	Manufacture of Fabricating and Processing Equipment (M-FPE)	0.645	80
3	Construction and Works (CW)	0.455	79
4	Manufacture of Basic Materials (M-BM)	0.452	41
5	Unclassified (U)	0.384	26
6	Information and Communications (S-IC)	0.236	18
7	General Services (S-G)	0.228	13
8	Wholesale and Retail Trade (WRT)	0.214	21
9	Financial and Insurance (FI)	0.143	10
10	Professional Technical Services (S-PT)	0.124	6
11	Business Management (S-BM)	0.115	5
12	Manufacture of Consumer Goods (M-CG)	0.085	5
13	Medical Institutions (MI)	0.081	5
14	Security System Services (S-SS)	0.046	2
15	Food Services (S-F)	0.011	1

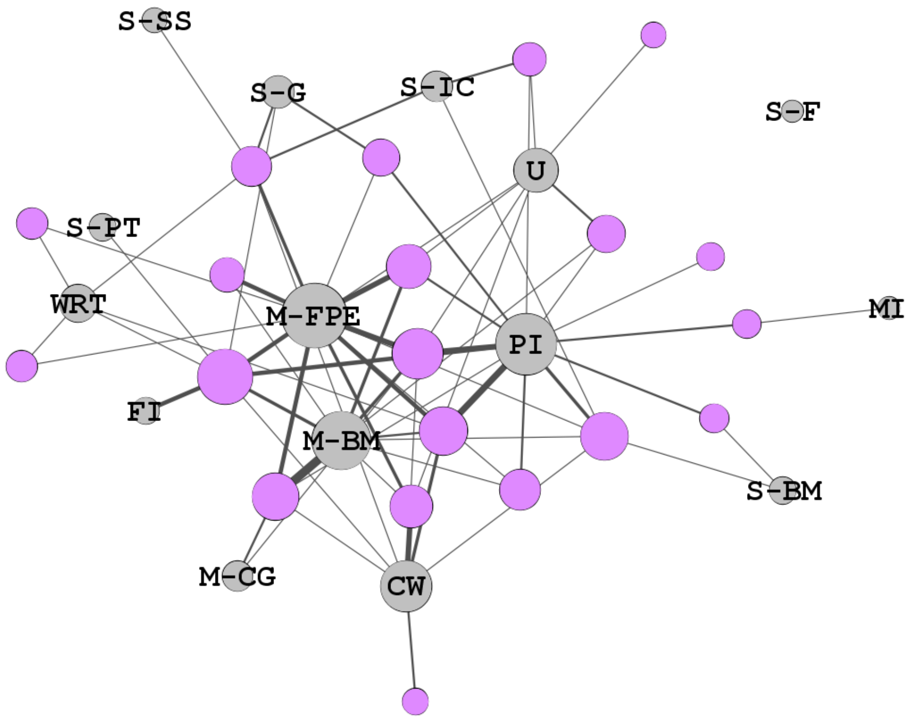


Figure 7. The trading network between companies in the industrial/construction safety field and their trading client types. The size of the node is proportional to the eigenvector centrality of each node. Thickness of edge is proportional to the weight.

Figure 7 illustrates the trading network between companies in the industrial/construction safety field and their trading organization types. 20 companies are in the industrial/construction safety field and 70 connections exist in the network. The average degree of the network is 4, and the average weighted degree is 8.171. The graph density is 0.118. As is assumed from Table 5 and *Figure 7*, the importance of M-FPE and M-BM is larger in the industrial/construction field than in the entire disaster-safety industry (see Table 5). The eigenvector centrality value of M-FPE is also ranked in the first place, and PI is ranked in the second place but still shows a high eigenvector centrality (0.916). That the eigenvector centrality of M-FPE is higher than that of PI means that the main customer group in the field of industrial/construction safety is composed mainly of private companies, which means that the market development potential is very high. It shows that the main customer of the industrial/construction safety field is manufacturing and construction companies, and the degree of connections with the tertiary industries are quite low. Since the sector covered by this industry is not a field that the service industry requires, rather than increasing the connections with the service industry, it is thought that the development should be centered on a wider manufacturing market, for example, overseas market development.

Table 5

Eigenvector centrality values by the industry type from the trading network between companies in the industrial/construction field and their trading client types.

Rank	Industry type	Eigenvector centrality	Weighted degree
1	Manufacture of Fabricating and Processing Equipment (M-FPE)	1.000	37
2	Public Institutions (PI)	0.916	32
3	Manufacture of Basic Materials (M-BM)	0.859	24
4	Construction and Works (CW)	0.688	15
5	Unclassified (U)	0.513	8
6	Wholesale and Retail Trade (WRT)	0.367	5
7	General Services (S-G)	0.253	5
8	Information and Communications (S-IC)	0.213	5
9	Manufacture of Consumer Goods (M-CG)	0.200	3
10	Business Management (S-BM)	0.127	2
11	Professional Technical Services (S-PT)	0.126	1
12	Financial and Insurance (FI)	0.126	4
13	Security System Services (S-SS)	0.070	1
14	Medical Institutions (MI)	0.027	1
15	Food Services (S-F)	0.000	0

Figure 8 illustrates the trading network between companies in the natural disaster prevention field and their client types. 17 companies are in the natural disaster prevention field and the network consists of 44 connections. The average degree of the network is 2.75, and the average weighted degree is 8.75. The graph density is 0.089. As is assumed from *Figure 8*, the importance of public institutions is overwhelmingly high (see Table 6). The eigenvector centrality value of M-FPE is still placed in the second place, but there is a huge difference in the eigenvector centrality, compared to that of PI. It means that the current natural disaster management industry relies heavily on trades with public institutions. In the case of the natural disaster prevention subdivision, there is not much demand from the private companies. By establishing related laws and policy support, the market size of the natural disaster prevention industry can be increased by making private companies invest more in natural disaster prevention. Since the companies in the natural disaster prevention subdivision have a lot of transactions with public institutions, especially with local municipalities, it is worth considering that the municipalities arrange for new transactions to their local companies.

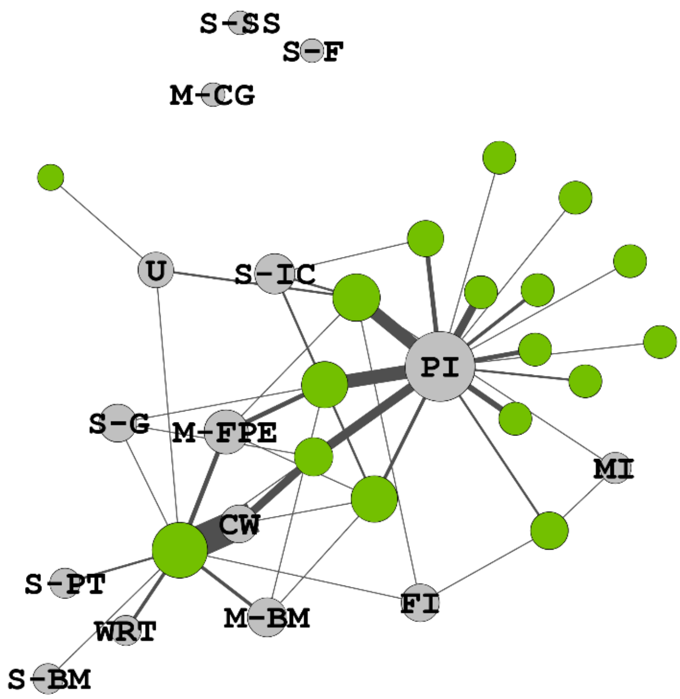


Figure 8. The trading network between companies in the natural disaster prevention field and their trading client types. The size of the node is proportional to the eigenvector centrality of each node. Thickness of edge is proportional to the weight.

Figure 9 illustrates the trading network between companies in the traffic safety field and their client types. 12 companies are in the natural disaster prevention field and the network consists of 21 connections. The average degree of the network is 1.57, and the average weighted degree is 3.93. The graph density is 0.06. The traffic safety subdivision also relies heavily on their sales to PI and M-FPE, as Table 7 illustrates. There are two main areas of traffic safety. One area is a road facility where demand is mainly generated by public institutions, and the other is a system for preventing traffic related accidents. These system products are mainly bought by the M-FPE industry. This seems to mean that high tech products can move away from traditional market of traffic safety, which relies on the demand of PI, and expand their market to a wider business area. In *Figure 9*, the companies that deal with the M-FPE industry are almost separated from the ones that deal with PI, it supports this claim. However, there is no transaction found between companies in the traffic safety and industry classifications of S-IC, S-F, S-SS, MI, WRT, and U. Although it cannot be generalized because the number of samples in the traffic safety field used in this study is quite small, it could mean that the industry type who makes demand of the traffic safety field may be very limited.

Table 6

Eigenvector centrality values by the industry type from the trading network between companies in the natural disaster prevention field and their trading client types.

Rank	Industry type	Eigenvector centrality	Weighted degree
1	Public Institutions (PI)	1.000	66
2	Manufacture of Fabricating and Processing Equipment (M-FPE)	0.443	10
3	Information and Communications (S-IC)	0.358	6
4	Manufacture of Basic Materials (M-BM)	0.338	5
5	Financial and Insurance (FI)	0.307	3
6	General Services (S-G)	0.306	3
7	Construction and Works (CW)	0.306	35
8	Unclassified (U)	0.259	4
9	Medical Institutions (MI)	0.166	2
10	Wholesale and Retail Trade (WRT)	0.141	3
11	Professional Technical Services (S-PT)	0.141	2
12	Business Management (S-BM)	0.141	1
13	Security System Services (S-SS)	0.000	0
14	Food Services (S-F)	0.000	0
15	Manufacture of Consumer Goods (M-CG)	0.000	0

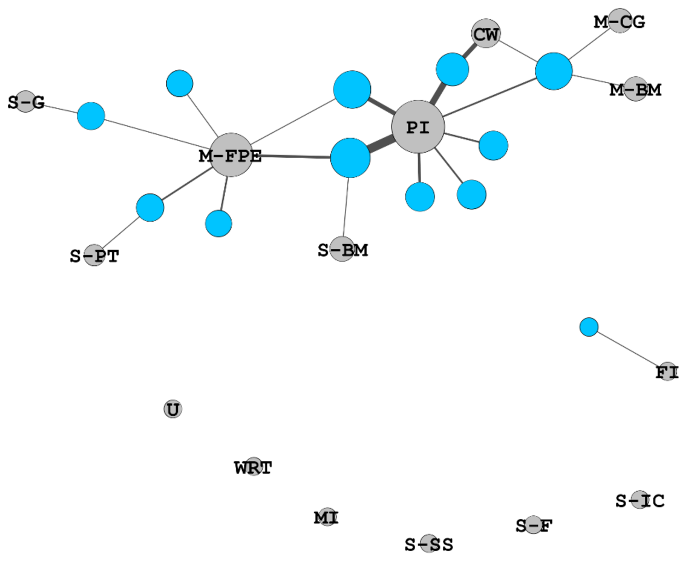


Figure 9. The trading network between companies in the traffic safety field and their trading client types. The size of the node is proportional to the eigenvector centrality of each node. Thickness of edge is proportional to the weight.

Figure 10 illustrates the trading network between companies in the fire safety field and their client types. 10 companies are in the fire safety field and the network consists of 23 connections. The average degree of the network is 1.84, and the average weighted degree is 3.92. The graph density is 0.077. As with other safety industries, the most important client type of the fire safety subdivision is PI, but their demands are relatively uniform across sectors, compared to other sectors of the safety industry (see Table 8). Although it cannot be revealed through the network analysis of *Figure 10*, it can be seen that many fire safety related companies are making non-continuous transactions rather than fixed dealings with specific clients. This characteristic is believed to contribute to the relatively even spread of the network. Another characteristic of the fire safety subdivision is this safety subdivision has a relatively higher proportion of wholesaler and retailer than other subdivisions. Therefore, the main customer of the fire safety subdivision is usually small businesses and individuals, which is not well presented in the network graph of this study.

Table 7

Eigenvector centrality values by the industry type from the trading network between companies in the traffic safety field and their trading client types.

Rank	Industry type	Eigenvector centrality	Weighted degree
1	Public Institutions (PI)	1.000	31
2	Manufacture of Fabricating and Processing Equipment (M-FPE)	0.731	10
3	Construction and Works (CW)	0.316	6
4	Business Management (S-BM)	0.201	1
5	Manufacture of Basic Materials (M-BM)	0.180	1
6	Manufacture of Consumer Goods (M-CG)	0.180	1
7	General Services (S-G)	0.095	1
8	Professional Technical Services (S-PT)	0.095	1
9	Financial and Insurance (FI)	0.012	1
10	Unclassified (U)	0.000	0
11	Information and Communications (S-IC)	0.000	0
12	Medical Institutions (MI)	0.000	0
13	Security System Services (S-SS)	0.000	0
14	Wholesale and Retail Trade (WRT)	0.000	0
15	Food Services (S-F)	0.000	0

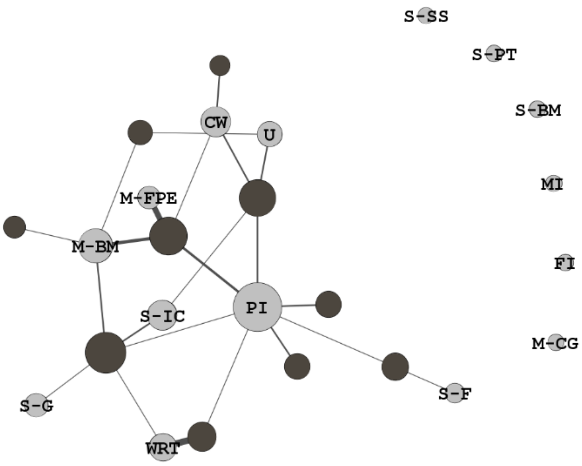


Figure 10. The trading network between companies in the fire safety field and their trading client types. The size of the node is proportional to the eigenvector centrality of each node. Thickness of edge is proportional to the weight.

Table 8

Eigenvector centrality values by the industry type from the trading network between companies in the fire safety field and their trading client types.

Rank	Industry type	Eigenvector centrality	Weighted degree
1	Public Institutions (PI)	1.000	12
2	Manufacture of Basic Materials (M-BM)	0.551	8
3	Construction and Works (CW)	0.425	5
4	Information and Communications (S-IC)	0.413	3
5	Wholesale and Retail Trade (WRT)	0.343	9
6	Unclassified (U)	0.267	3
7	General Services (S-G)	0.224	1
8	Manufacture of Fabricating and Processing Equipment (M-FPE)	0.195	7
9	Food Services (S-F)	0.100	1
10	Manufacture of Consumer Goods (M-CG)	0.000	0
11	Business Management (S-BM)	0.000	0
12	Medical Institutions (MI)	0.000	0
13	Financial and Insurance (FI)	0.000	0
14	Security System Services (S-SS)	0.000	0
15	Professional Technical Services (S-PT)	0.000	0

5. Discussion

Table 9 summarizes the network indexes for each disaster safety subdivision. Through these indexes, the characteristics of each subdivision can be understood. The average degree is an indicator which measures how many client types a company in the subdivision is dealing with. The average weighted degree is an indicator which measures how many clients a company in the subdivision is dealing with, because it uses the number of transacting clients as a weight. The average employee and sales can be used as indicators of the size of the company. As a result of the analysis, it was found that most companies belong to the industrial/construction safety subdivision, and the average sales of that subdivision were also high. The number of companies in the natural disaster prevention subdivision is the second most followed by those in the industrial/construction safety subdivision. When looking at the average degree, it can be argued that the industrial/construction safety subdivision have the widest range of market in terms of their wide client types. The average number of clients of each company is highest in the natural disaster prevention subdivision, but the average degree of the natural disaster prevention subdivision is relatively low. It means the company in the natural disaster prevention subdivision deals with a wide range of clients, but the industrial diversity of clients is quite narrow. Although the average sales of the security sector are the highest, this is due to a bias in the data due to the small number of samples and it cannot reflect the general characteristics of the security subdivision.

As a result of analyzing the current status and characteristics of trading networks of the disaster-safety industry in Korea focusing on demand, the public institutes are the most important client type of the disaster-safety industry. However, this trend is slightly different depending on the specific subdivision within the disaster safety industry. In this study, the subdivisions are classified according to the disaster-safety topic of companies. They are not based on traditional industrial categories such as manufacturing and service, but on the theme of the disaster-safety industry, such as natural disaster prevention and traffic safety. When the overall disaster-safety industry is analyzed, it is shown that public institutions are in the most important position, by their eigenvector centrality value. However, when the network is separated by the disaster-safety subdivision area, the importance of public institutions is not the greatest in all networks. This is also consistent with the results of the survey. In the subdivisions of the disaster-safety industry other than the natural disaster prevention subdivision, the respondents were more likely to respond that their main trading client type was other businesses, rather than the governmental agencies and public enterprises. Similar results were obtained in the detailed network analyses by subdivisions.

In the industrial/construction safety subdivision, the manufacturing of fabricating and processing equipment industry is the most important client type, more important than the public institutions. Also, it is found that the overall manufacturing sector and the construction and works industry are taking relatively more important positions in the industrial/construction safety subdivision. Because the largest customer type of the industrial/construction safety subdivision is the private industry rather than the public organizations and this safety subdivision also has wider range of market, it can be said that the industrial/construction safety subdivision has the highest market potential.

However, as expected, in the case of traditional natural disaster prevention, the importance of public institutions in the network has been overwhelmingly high, and further research to find a way to increase the demand for natural disaster prevention in private industries needs to be conducted. Because the natural disaster prevention subdivision is highly relying their business on the public institutes, this safety subdivision can be effectively developed through the government leaded fostering strategies. Another advantage of this approach is that it is expected that the cooperation between the two groups, the natural disaster prevention subdivision and the public institutes, will be successful because this subdivision and the government agencies have already established strong mutual relations with each other.

Analysis of the traffic safety subdivision reveals that even companies that deal with the same topic of traffic safety can differentiate their trading networks according to their product characteristics. This supports the need for high-value-added service industries and the high-tech industry in the disaster-safety industry whose importance have been raised in previous research. By fostering industries that require a high level of technology, the market for the disaster-safety industry, which is currently focused on the simple manufacturing industry, can be much broader. In the data used in this study, there are many wholesalers and manufacturers in the fire safety subdivision. This made it difficult to grasp the industrial structure of the fire safety subdivision through the network analysis, and further study on the fire safety field will be needed in the future.

In the disaster-safety industry as a whole, it is found that transactions with the service industry were relatively low. Therefore, finding a role of the disaster-safety industry for the service industry and developing capacity for that role is considered to be one of the ways for the growth of the disaster-safety industry. To widen the market of the disaster-safety industry, there is a way to broaden the market focusing on industrial fields that are not actively engaged in current transactions, for example, service industries as it is mentioned. However, since the size of the domestic market is not so large, it is necessary to make an export promotion policy as has been suggested in the a lot of previous research. The interviews in this study also suggest the importance of exports, because many interviewed companies mentioned exports as a desired transaction in the future.

Table 9

Summary of overall indices for the networks of the disaster-safety industry and its sub-divisions.

Industry sub-division	Number of companies	Number of connections	Average degree	Average weighted degree	Graph density	Average employee	Average sales (unit: billion)
Entire industry	82	220	4.536	10.371	0.047	23.8	5.13
Industrial/ construction safety	20	70	4.000	8.171	0.118	18.6	5.11
Natural disaster prevention	17	44	2.750	8.75	0.089	18.2	4.07
Traffic safety	13	25	1.786	4.357	0.066	21.3	2.47
Fire safety	10	23	1.840	3.92	0.077	16.4	2.91
Living safety	9	21	1.750	2.583	0.076	13.2	1.15
Security	9	25	2.083	4.25	0.091	71.8	21.40
Hygiene/Health	2	6	0.706	0.941	0.044	10.0	1.50
Miscellaneous	2	6	0.706	2.353	0.044	18.0	1.50

6. Conclusion

As society changes, the importance and necessity of private sector participation in disaster safety management is getting bigger. The purpose of this study is to analyze the present market situation of the disaster-safety industry in Korea and to suggest the future direction of the disaster safety industry.

In this study, the structure of the disaster-safety industry is analyzed using the social network analysis approach for each subdivision, and the possibility of the future fostering direction is suggested. The results of this study show that the disaster-safety industry tends to depend highly on the demand of public institutions. The importance of the public institutions means that disaster-safety industry can be developed effectively through government policy, because they already have closer relationships. However, to promote the industry, it is essential to advance the market into the private sector. As shown in this study, considering the high demand for disaster-safety industry in high-tech industry (M-FPE), it is necessary to develop industry fostering strategies which target these industries. Also, considering the overall companies in the disaster-safety industry do not deal well with the service industry, it is necessary to find out the role of the disaster safety management industry required by the service industry

The outcomes of this study are expected to help researchers to understand the current state of the Korean disaster-safety industry deeper, and widen the application of the social network analysis on the industry analysis. There also several limitations of this study which wasn't covered in the study and needed further study in the future. First, there is no connection between companies in the disaster-safety industry and between clients, this limitation is caused by the way data collected. A similar limitation is that the list of clients can be differentiated by the interviewees' knowledge of their company. Second, further analysis as the view from business, for example, adopting concepts like supply chain, is needed to find the way to grow the disaster-safety industry more directly. Also, Further study using some statistical analyses and an objective way to interpret the networks, including the interpretations of eigenvector centrality are needed to support the result of this study

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APPENDIX

APPENDIX A. The semi-structured interview form

울산과학기술원 UDI 울산발전연구원 【재난안전산업 현황 조사】

ID

국내 재난안전산업 현황 설문조사

안녕하십니까?

이번에 울산과학기술원(UNIST) 도시환경공학부에서는 울산광역시 과업의 일환으로「울산 재난안전산업 육성 기본계획 수립」연구를 수행하고 있습니다. 본 연구는 국내 재난안전산업 현황을 파악, 이에 맞는 산업육성계획을 수립하는 것을 목표로 이루어지고 있는 연구입니다.

본 연구의 일환으로 대한민국 안전산업박람회에 참여한 업체를 대상으로 귀사의 산업 현황 및 산업 네트워크에 대한 설문조사를 실시하오니, 적극적인 참여를 부탁드립니다.

응답하신 내용은 재난안전산업 육성 방안을 모색하는데 필요한 귀중한 자료이니 바쁘시더라도 반드시 응답해 주시면 감사드리겠습니다. 본 설문의 내용과 응답사항은 통계법 제33조(비밀의 보호)에 의해 보호되며, 연구 이외의 다른 목적으로 사용되지 않을 것임을 약속드립니다. 설문에 대한 의문사항이 있으시면 아래로 연락주시기 바랍니다.

감사합니다.

2016년 11월

울산과학기술원

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- 1 -

응답자 사업체 기본사항

1. 사업체 정보를 기입해주시길 바랍니다.

기업명		분야	
사업체 유형			

2. 귀사의 종업원 현황에 대해 기입해 주시기 바랍니다. (현재 기준)

종업원 수: __________ 명

3. 귀사의 대략적인 작년 매출은 어느 정도였습니까? (2015년)

작년도 매출: __________ 천만 원

(1억 미만 / 1억이상 - 10억미만 / 10억이상 – 20억미만 / 20억이상 – 50억미만 / 50억 이상)

Ⅰ 재난안전산업 현황 조사

1. 귀사는 현재 재난안전산업과 타 사업을 겸업하고 있습니까?

① 재난안전산업 전업

② 재난안전산업과 기타 사업과의 겸업

③ 재난안전산업에 해당되지 않음

*기타 사업과의 경업은 재난안전산업 업종 외의 업종을 같이 영위할 경우를 의미함

2. 귀사의 현재 주요 사업분야는 재난안전산업입니까?

① 그렇다

② 아니다

3. 과거 귀사의 주요 사업분야는 무엇이었습니까? 가능한 구체적으로 기록해주세요.

(재난안전산업으로 창업하지 않은 경우 응답/ 제조, 건설·설계, 도소매, 관리, 서비스업 등)

____

Ⅲ 재난안전산업 산업체 네트워크 조사

1. 귀사가 주로 거래하는 대상은 다음 중 어떤 유형입니까?

① 정부

② 기업

③ 개인

④ 기타 ____________________

2. 귀사의 주요 거래처에 대한 정보를 아래 표에 기입하여 주십시오.

거래처 이름	거래처 유형	지역	관계

작성 예시)

거래처 이름	거래처 유형	지역	관계
국민안전처	정부기관	세종특별시	협동연구(R&D)
A시청	정부기관	AA도 A시	발주처
OO산업	사업체	OO도 OO시	물품 납품
XX산업	하청업체	XX도 XX시	원자재 납품

3. 귀사에게 있어 주요 입찰 시 빈번히 만나는 업체(경쟁사)가 있다면 아래 표에 그 정보를 상세히 기입하여 주십시오,

경쟁사 이름	경쟁사 유형	지역	관계

4. 귀사에서 향후 거래를 희망하는 기관·거래처가 있으십니까?

거래처 이름	거래처 유형	지역	관계

5. 귀사에서는 제품 및 기술개발 등을 목적으로 연구개발(R&D)을 진행하십니까?

① 그렇다 (자체연구소 및 연구부서 / 외부연구소 / 대학교 등 연구(교육)기관 / 기타)
② 아니다

6. 귀사에서 진행하는 연구개발(R&D)은 어떤 단체와 진행하였습니까?

협력단체 이름	협력단체 유형	지역

Ⅳ 재난안전산업 클러스터 참여 의향 조사

1. 귀사에게 있어 현재의 사업체 위치는 어떤 의미에서 중요성을 가집니까?

____

(응답 예시: 물류운송, 고객만남, 주변산업체, 지자체지원 등)

2. 귀사는 사업체 입지 선정 시 어떤 요소가 가장 중요하다고 생각하십니까?

____

(응답 예시: 물류운송, 고객만남, 주변산업체, 지자체지원 등)

3. 귀사는 현재 입지보다 더 좋은 조건의 입지가 있다면 사업체를 이전할 의향이 있습니까?

① 그렇다 (희망지역: ______________ / 가장 중요한 입지요소: ______________)

② 아니다 (이전하지 않는 이유가 있다면? ______________________________)

▣ 설문에 성실히 응해주셔서 대단히 감사합니다. ▣